

IN THE CLAIMS

Please cancel claims 2, 4, 5, 6, 12, 14, 15, 16, 23, 24, 25, and 26, and amend claims 1, 11, and 21 as follows:

1. (CURRENTLY AMENDED) A method of estimating a momentum to be removed from a spacecraft:

generating a plurality of spacecraft momentum measurements;

fitting the plurality of spacecraft momentum measurements to a parametric model of a spacecraft momentum profile having a time period of  $t_p$ ;

determining the momentum of the spacecraft from the parametric model; and

generating an estimate of the momentum to be removed from the spacecraft at least in part from the determined momentum of the spacecraft;

wherein the generating a plurality of spacecraft momentum measurements comprises

measuring the spacecraft angular rate;

measuring an angular rate of a momentum storage device disposed in the satellite;

and

computing the momentum of the spacecraft at least in part from the spacecraft angular rate, the momentum storage device angular rate, and an inertia of the spacecraft and an inertia of the momentum storage device[.]; and

wherein the period spacecraft momentum profile comprises a plurality of segments, each segment modeled by a set of basis functions selected from the group comprising a 3<sup>rd</sup> order polynomial, and each segment is an hour in duration.

2. (CANCELED)

3. (ORIGINAL) The method of claim 1, further comprising the step of filtering the plurality of spacecraft momentum measurements before fitting the spacecraft momentum measurements to the parametric model.

4. (CANCELED)

5. (CANCELED)

6. (CANCELED)

7. (ORIGINAL) The method of claim 1, wherein the step of estimating the amount of momentum to be removed from the spacecraft comprises the steps of:

determining a secular momentum residual at least in part from the momentum of the spacecraft determined from the parametric model;

determining a momentum bias error; and

determining the amount of momentum to be removed from the spacecraft at least in part from the measured momentum bias error and the secular momentum residual.

8. (ORIGINAL) The method of claim 7, wherein the step of determining a secular momentum residual at least in part from the momentum of the spacecraft comprises the steps of:

filtering the spacecraft momentum measurements; and

determining a difference between a spacecraft momentum measurement at a scheduled time for removing the momentum from the spacecraft and the estimate of the spacecraft momentum at a time one time period  $t_p$  prior to the scheduled time for removing the momentum from the spacecraft.

9. (PREVIOUSLY PRESENTED) The method of claim 8, wherein the step of determining a momentum bias error comprises the steps of:

determining the measured momentum bias at least in part from  $\frac{M_{MAX} + M_{MIN}}{2}$ , wherein

$M_{MAX}$  is the maximum momentum observed during the time period  $t_p$  and  $M_{MIN}$  is a minimum momentum observed during the time period  $t_p$ ; and

determining the momentum bias error as a difference between the measured momentum bias and a commanded momentum bias.

10. (ORIGINAL) The method of claim 9, wherein spacecraft momentum is at least partially periodic with time period  $t_p$ .

11. (CURRENTLY AMENDED) An apparatus for estimating a momentum to be removed from a spacecraft:

- means for generating a plurality of spacecraft momentum measurements;
- means for fitting the plurality of spacecraft momentum measurements to a parametric model of a spacecraft momentum profile having a time period of  $t_p$ ;
- means for determining the momentum of the spacecraft from the parametric model; and
- means for generating an estimate of the momentum to be removed from the spacecraft at least in part from the determined momentum of the spacecraft;

wherein the spacecraft comprises a momentum storage device, and wherein the means for generating a plurality of spacecraft momentum measurements comprises

- means for measuring the spacecraft angular rate;
- means for measuring an angular rate of a momentum storage device disposed in the satellite; and
- means for computing the momentum of the spacecraft at least in part from the spacecraft angular rate, the momentum storage device angular rate, and an inertia of the spacecraft and an inertia of the momentum storage device[.]; and

wherein the period spacecraft momentum profile comprises a plurality of segments, each segment modeled by a set of basis functions selected from the group comprising a 3<sup>rd</sup> order polynomial, and each segment is an hour in duration.

12. (CANCELED)

13. (ORIGINAL) The apparatus of claim 11, further comprising means for filtering the plurality of spacecraft momentum measurements before fitting the spacecraft momentum measurements to the parametric model.

14. (CANCELED)

15. (CANCELED)

16. (CANCELED)

17. (ORIGINAL) The apparatus of claim 11, wherein the means for estimating the amount of momentum to be removed from the spacecraft comprises:

means for determining a secular momentum residual at least in part from the momentum of the spacecraft determined from the parametric model;

means for determining a momentum bias error; and

means for determining the amount of momentum to be removed from the spacecraft at least in part from the measured momentum bias error and the secular momentum residual.

18. (ORIGINAL) The apparatus of claim 17, wherein the means for determining a secular momentum residual at least in part from the momentum of the spacecraft comprises:

means for filtering the spacecraft momentum measurements; and

means for determining a difference between a spacecraft momentum measurement at a scheduled time for removing the momentum from the spacecraft and the estimate of the spacecraft momentum at a time one time period  $t_p$  prior to the scheduled time for removing the momentum from the spacecraft.

19. (PREVIOUSLY PRESENTED) The apparatus of claim 18, wherein the means for determining a momentum bias error comprises:

means for determining the measured momentum bias at least in part from  $\frac{M_{MAX} + M_{MIN}}{2}$ ,

wherein  $M_{MAX}$  is the maximum momentum observed during the time period  $t_p$  and  $M_{MIN}$  is a minimum momentum observed during the time period  $t_p$ ; and

means for determining  $[[a]]$  the momentum bias error as a difference between the measured momentum bias and a commanded momentum bias.

20. (ORIGINAL) The apparatus of claim 19, wherein spacecraft momentum is at least partially periodic with time period  $t_p$ .

21. (CURRENTLY AMENDED) An apparatus for estimating a momentum to be removed from a spacecraft:

a first module for accepting a plurality of spacecraft momentum measurements and for fitting the plurality of spacecraft momentum measurements to a parametric model of a spacecraft momentum profile having a time period of  $t_p$ ;

a second module for determining the momentum of the spacecraft from the parametric model;

a third module for generating an estimate of the momentum to be removed from the spacecraft at least in part from the determined momentum of the spacecraft; and

a filter for filtering the plurality of spacecraft momentum measurements before fitting the spacecraft momentum measurements to the parametric model [1.]; and

wherein the period spacecraft momentum profile comprises a plurality of segments, each segment modeled by a set of basis functions selected from the group comprising a 3<sup>rd</sup> order polynomial, and each segment is an hour in duration.

22. (ORIGINAL) The apparatus of claim 21, further comprising a processor, and wherein the first module, the second module, and the third module are software modules comprising instructions performable by the processor.

23. (CANCELED)

24. (CANCELED)

25. (CANCELED)

26. (CANCELED)

27. (ORIGINAL) The apparatus of claim 21, wherein the third module comprises:  
a fourth module for determining a secular momentum residual at least in part from the momentum of the spacecraft determined from the parametric model;  
a fifth module for determining a momentum bias error; and  
a sixth module for determining the amount of momentum to be removed from the spacecraft at least in part from the measured momentum bias error and the secular momentum residual.

28. (ORIGINAL) The apparatus of claim 27, wherein:  
the apparatus further comprises a filter for filtering the spacecraft momentum measurements; and  
the fourth module comprises a differencer for determining a difference between a spacecraft momentum measurement at a scheduled time for removing the momentum from the spacecraft and the estimate of the spacecraft momentum at a time one time period  $t_p$  prior to the scheduled time for removing the momentum from the spacecraft.

29. (PREVIOUSLY PRESENTED) The apparatus of claim 27, wherein the fifth module comprises:  
a seventh module for determining the measured momentum bias at least in part from  $\frac{M_{MAX} + M_{MIN}}{2}$ , wherein  $M_{MAX}$  is the maximum momentum observed during the time period  $t_p$  and  $M_{MIN}$  is a minimum momentum observed during the time period  $t_p$ ; and  
an eighth module for determining [[a]] the momentum bias error as a difference between the measured momentum bias and a commanded momentum bias.

30. (ORIGINAL) The apparatus of claim 29, wherein spacecraft momentum is at least partially periodic with time period  $t_p$ .

31. (PREVIOUSLY PRESENTED) A method of estimating a momentum to be removed from a spacecraft:

- generating a plurality of spacecraft momentum measurements;
- fitting the plurality of spacecraft momentum measurements to a parametric model of a spacecraft momentum profile having a time period of  $t_p$ ;
- determining the momentum of the spacecraft from the parametric model; and
- generating an estimate of the momentum to be removed from the spacecraft at least in part from the determined momentum of the spacecraft;

wherein the step of estimating the amount of momentum to be removed from the spacecraft comprises the steps of:

- determining a secular momentum residual at least in part from the momentum of the spacecraft determined from the parametric model;
- determining a momentum bias error; and
- determining the amount of momentum to be removed from the spacecraft at least in part from the measured momentum bias error and the secular momentum residual.

32. (PREVIOUSLY PRESENTED) The method of claim 31, wherein the step of determining a secular momentum residual at least in part from the momentum of the spacecraft comprises the steps of:

- filtering the spacecraft momentum measurements; and
- determining a difference between a spacecraft momentum measurement at a scheduled time for removing the momentum from the spacecraft and the estimate of the spacecraft momentum at a time one time period  $t_p$  prior to the scheduled time for removing the momentum from the spacecraft.



33. (PREVIOUSLY PRESENTED) The method of claim 32, wherein the step of determining a momentum bias error comprises the steps of:

determining the measured momentum bias at least in part from  $\frac{M_{MAX} + M_{MIN}}{2}$ , wherein

$M_{MAX}$  is the maximum momentum observed during the time period  $t_p$  and  $M_{MIN}$  is a minimum momentum observed during the time period  $t_p$ ; and

determining the momentum bias error as a difference between the measured momentum bias and a commanded momentum bias.

34. (PREVIOUSLY PRESENTED) The method of claim 33, wherein spacecraft momentum is at least partially periodic with time period  $t_p$ .

35. (PREVIOUSLY PRESENTED) The method of claim 31, wherein the spacecraft comprises a momentum storage device, and wherein the step of generating a plurality of spacecraft momentum measurements comprises the steps of:

measuring the spacecraft angular rate;

measuring an angular rate of a momentum storage device disposed in the satellite; and

computing the momentum of the spacecraft at least in part from the spacecraft angular rate, the momentum storage device angular rate, and an inertia of the spacecraft and an inertia of the momentum storage device.

36. (PREVIOUSLY PRESENTED) The method of claim 31, further comprising the step of filtering the plurality of spacecraft momentum measurements before fitting the spacecraft momentum measurements to the parametric model.

37. (PREVIOUSLY PRESENTED) The method of claim 31, wherein the periodic spacecraft momentum profile comprises a plurality of segments, each segment modeled by a set of basis functions.

38. (PREVIOUSLY PRESENTED) The method of claim 37, wherein the set of basis functions is selected from the group comprising:

- a polynomial; and
- a Fourier series.

39. (PREVIOUSLY PRESENTED) The method of claim 38, wherein the set of basis functions is a 3<sup>rd</sup> order polynomial, and each segment is one hour in duration.

40. (PREVIOUSLY PRESENTED) An apparatus for estimating a momentum to be removed from a spacecraft:

- means for generating a plurality of spacecraft momentum measurements;
- means for fitting the plurality of spacecraft momentum measurements to a parametric model of a spacecraft momentum profile having a time period of  $t_p$ ;
- means for determining the momentum of the spacecraft from the parametric model; and
- means for generating an estimate of the momentum to be removed from the spacecraft at least in part from the determined momentum of the spacecraft;
- wherein the means for estimating the amount of momentum to be removed from the spacecraft comprises:
  - means for determining a secular momentum residual at least in part from the momentum of the spacecraft determined from the parametric model;
  - means for determining a momentum bias error; and
  - means for determining the amount of momentum to be removed from the spacecraft at least in part from the measured momentum bias error and the secular momentum residual.

41. (PREVIOUSLY PRESENTED) The apparatus of claim 40, wherein the means for determining a secular momentum residual at least in part from the momentum of the spacecraft comprises:

means for filtering the spacecraft momentum measurements; and  
means for determining a difference between a spacecraft momentum measurement at a scheduled time for removing the momentum from the spacecraft and the estimate of the spacecraft momentum at a time one time period  $t_p$  prior to the scheduled time for removing the momentum from the spacecraft.

42. (PREVIOUSLY PRESENTED) The apparatus of claim 41, wherein the means for determining a momentum bias error comprises:

means for determining the measured momentum bias at least in part from  $\frac{M_{MAX} + M_{MIN}}{2}$ ,

wherein  $M_{MAX}$  is the maximum momentum observed during the time period  $t_p$  and  $M_{MIN}$  is a minimum momentum observed during the time period  $t_p$ ; and

means for determining the momentum bias error as a difference between the measured momentum bias and a commanded momentum bias.

43. (PREVIOUSLY PRESENTED) The apparatus of claim 42, wherein spacecraft momentum is at least partially periodic with time period  $t_p$ .

44. (PREVIOUSLY PRESENTED) The apparatus of claim 40, wherein the spacecraft comprises a momentum storage device, and wherein the means for generating a plurality of spacecraft momentum measurements comprises:

means for measuring the spacecraft angular rate;

means for measuring an angular rate of a momentum storage device disposed in the satellite;

and

means for computing the momentum of the spacecraft at least in part from the spacecraft angular rate, the momentum storage device angular rate, and an inertia of the spacecraft and an inertia of the momentum storage device.

45. (PREVIOUSLY PRESENTED) The apparatus of claim 40, further comprising means for filtering the plurality of spacecraft momentum measurements before fitting the spacecraft momentum measurements to the parametric model.

46. (PREVIOUSLY PRESENTED) The apparatus of claim 40, wherein the periodic spacecraft momentum profile comprises a plurality of segments, each segment modeled by a set of basis functions.

47. (PREVIOUSLY PRESENTED) The apparatus of claim 46, wherein the set of basis functions is selected from the group comprising:

a polynomial; and

a Fourier series.

48. (PREVIOUSLY PRESENTED) The apparatus of claim 47, wherein the set of basis functions is a 3<sup>rd</sup> order polynomial, and each segment is one hour in duration.

49. (PREVIOUSLY PRESENTED) An apparatus for estimating a momentum to be removed from a spacecraft:

a first module for accepting a plurality of spacecraft momentum measurements and for fitting the plurality of spacecraft momentum measurements to a parametric model of a spacecraft momentum profile having a time period of  $t_p$ ;

a second module for determining the momentum of the spacecraft from the parametric model; and

a third module for generating an estimate of the momentum to be removed from the spacecraft at least in part from the determined momentum of the spacecraft;

wherein the third module comprises:

a fourth module for determining a secular momentum residual at least in part from the momentum of the spacecraft determined from the parametric model;

a fifth module for determining a momentum bias error; and

a sixth module for determining the amount of momentum to be removed from the spacecraft at least in part from the measured momentum bias error and the secular momentum residual.

50. (PREVIOUSLY PRESENTED) The apparatus of claim 49, wherein:  
the apparatus further comprises a filter for filtering the spacecraft momentum measurements; and

the fourth module comprises a differencer for determining a difference between a spacecraft momentum measurement at a scheduled time for removing the momentum from the spacecraft and the estimate of the spacecraft momentum at a time one time period  $t_p$  prior to the scheduled time for removing the momentum from the spacecraft.

51. (PREVIOUSLY PRESENTED) The apparatus of claim 49, wherein the fifth module comprises:

a seventh module for determining the measured momentum bias at least in part from  $\frac{M_{MAX} + M_{MIN}}{2}$ , wherein  $M_{MAX}$  is the maximum momentum observed during the time period  $t_p$  and  $M_{MIN}$  is a minimum momentum observed during the time period  $t_p$ ; and

an eighth module for determining the momentum bias error as a difference between the measured momentum bias and a commanded momentum bias.

52. (PREVIOUSLY PRESENTED) The apparatus of claim 51, wherein spacecraft momentum is at least partially periodic with time period  $t_p$ .

53. (PREVIOUSLY PRESENTED) The apparatus of claim 49, further comprising a processor, and wherein the first module, the second module, and the third module are software modules comprising instructions performable by the processor.

54. (PREVIOUSLY PRESENTED) The apparatus of claim 49, further comprising a filter for filtering the plurality of spacecraft momentum measurements before fitting the spacecraft momentum measurements to the parametric model.

55. (PREVIOUSLY PRESENTED) The apparatus of claim 49, wherein the periodic spacecraft momentum profile comprises a plurality of segments, each segment modeled by a set of basis functions.

56. (PREVIOUSLY PRESENTED) The apparatus of claim 55, wherein the set of basis functions is selected from the group comprising:

- a polynomial; and
- a Fourier series.

57. (PREVIOUSLY PRESENTED) The apparatus of claim 56, wherein the set of basis functions is a 3<sup>rd</sup> order polynomial, and each segment is one hour in duration.